Advancements in Data-Acquisition and Monitoring Devices for silos through the Internet of Things

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ABSTRACT

The recent introduction of the Internet of Things (IoT) has significantly impacted agriculture, allowing real-time farm and storage monitoring. This study focuses on IoT applications in grain storage, tackling challenges like spatial data, environmental variability, and mobile integration. An IoT-based system for corn storage was developed, employing a MySQL database and Arduino for data interaction, enhanced by an Android app for remote monitoring. Tested in a standardized silo, the system demonstrated anticipated effectiveness in improving grain storage management.

1. Introduction

Maintaining the security of grain storage has grown increasingly dependent on the capacity to send information and monitor grain conditions. Having sufficient, safe grain supplies is essential. Nevertheless, improper storage causes a 7-15% loss in grain that is post-harvest stored [1]. It is crucial to put in place a system to guarantee a suitable and sufficient storage system since because it has been the most eaten food throughout the years, chemical methods of storing it for a longer period might cause deficiencies when ingested. While whole grains' beneficial oils can be adversely impacted by heat, light, and moisture, which can lead to germ in the grain mass, whole grains need to be stored with a little more prudence than their refined counterparts. The presence of pests, microbes, and fungus in grain results from the incapacity to consider the environmental conditions of the storage facility, such as the temperature, humidity, moisture content, and level of gases like CO_2. The main factors for grain to decompose because of increased metabolic activity and insect proliferation inside the grain mass are humidity, temperature, and grain moisture content [2].

2. Method

The recent technological advancement has created an efficient and adequate monitoring and security system for our day-to-day activities. Considering the monitoring and security challenges encountered in storage facilities, there is a need to analyze data and transmit information over network to the remote locations. In design, grain monitoring is done where sensors are used to collect information in the storage aspect of the agricultural field. This system makes use of the Internet of Things (IoT) which can transmit data in real-time to facilitate grain monitoring for the protection of the grain so that it would not get contaminated due to the surrounding conditions during storage. Efficient monitoring of temperature, humidity, moisture content and other conditions without being present physically at the location helps us to get a better outcome. Here, the main purpose is to observe, secure and monitor the storage environment thus making the admin manage the data in real-time. Figure 1 shows the block diagram of the system.

The design implementation of this study is divided into two phases:
Hardware Implementation
Software Implementation
Under this section,

- The technical procedures,
- sensors to be employed,
- system integration, and
- flowchart,

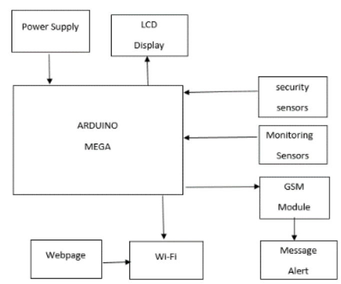


Figure 1: System Block Diagram

Figure 1 shows the schematic diagram of the different functional interfaces that make up the hardware subsystem comprising of the sensor units, the microcontroller units and power supply units. Hardware design focused on processing the signal coming from the sensors using microcontroller technology. The system block diagram describes the relationship between the sensors and the processor and is divided into six units:

i. Power supply unit: The power supply unit converts alternating-current AC from a wall socket to a low-voltage direct-current DC also known as rectification to operate the processor and peripheral devices and also charges the battery. Here, both the A.C supply and the D.C supply are put into consideration for the efficiency of the device.

ii. Processing Unit: This unit is made up of a microcontroller and it is the major brain of the system where instructions are passed to control both the input and output activities in the system. Here Arduino ATMEGA328 was chosen for this purpose.
iii. Sensing Unit: This is the unit that is responsible for the detection of environmental changes and sends the information to the microcontroller. This comprises the Temperature sensor, Humidity sensor, Moisture content sensor, Passive infrared sensor (PIR) and Flame sensor for monitoring and security.
iv. Transmitting Unit: The information sensed by the sensors are transmitted in this unit to the receiving end, this unit is made of the GSM/GPRS module.
v. Data-Collection Unit: This is also known as the Reception unit, where the information transmitted is received, here a user-friendly Mobile app is developed and the information can also be saved in the system SD card.
vi. Switching Unit: This is majorly where the controlling operation is done to maintain the optimum parameter values of the physical environmental factors in the storage facility. This comprises of Electro-magnetic relay, normally an open push-button and a Reset button.

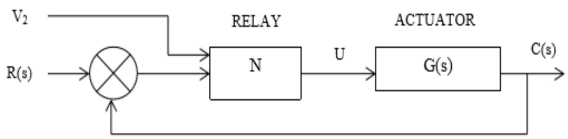
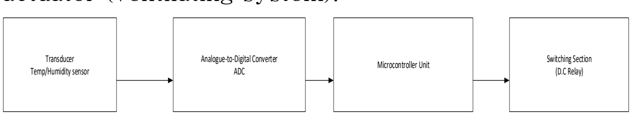


Figure 2: Control System Block Diagram

A relay is a nonlinear power amplifier that can provide large power amplification inexpensively (Nagrath and Gopal, 2011). The relays introduce some nonlinearity into the system; they switch abruptly between two states, i.e. the ON-OFF states. Hence this nonlinearity is considered when dealing with the responses of the actuator (ventilating system).



The physical parameters such as temperature and humidity are analogue. To convert a continuously varying physical quantity into electrical signals, we need an analogue-to-digital converter to translate the analogue signals to digital numbers so that the microcontroller can read them. Thus, an analogue-to-digital converter (ADC) is an electronic circuit that converts continuous signals to discrete digital numbers. Analog-to-digital converters are the most widely used devices for data acquisition. The ADC achieves conversion by summing up the analogue signal to a particular level called STEP SIZE. The Step size is the smallest voltage change that can be measured by an ADC. It is a function of the set reference voltage Vref and the resolution of the ADC as shown in

$$\text{Step size} = \frac{V_{(Ref)}}{2^{(resolution)} - 1} \quad (2)$$

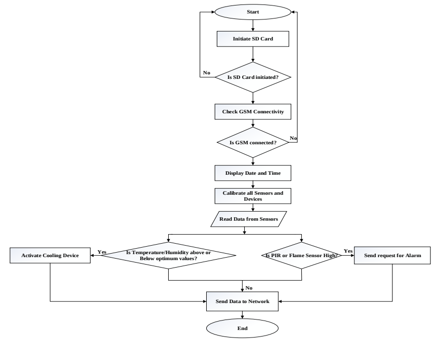


Figure 4: System Flowchart

3. Conclusion

In summary, parameters including temperature, humidity, and moisture content need to be managed for optimal grain storage. These elements primarily impact molds, insects, and other pests that cause large losses of grain in a short amount of time. As a consequence, they are the principal causes of grain degradation. As a result, grain affected by fungus and molds can produce toxins in addition to discoloring the grain and making it unsuitable for human consumption. Regular monitoring of grain is necessary to prevent mycotoxin contamination and provide safe storage conditions. The result obtained further shows that temperature, humidity, and moisture content contributed to losses in the weight of the grain stored if not monitored and maintained during the research period.

This research was supported by Yura Corporation ((2024-0043-01) The study on product design and design guide derivation based on Rigid PCB Pattern Fuse design specifications) And Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant-funded by the Korea government (MOTIE) (No. 2021050101 0020, Development on MMC-based ESS and Core Device s of High Voltage Hub-Station Grid-Connected with Renewable Energy Source).

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